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UTION FROM THE YALE SCHOOL
OF FORESTRY, No. 9

THE WOOD OF MACHAERIUM WHITFORDII

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The wood of Machaerium Whitfordii*

Robert B. Miller

(with eight text figures)

Material

The specimen of wood described in this paper is from the type tree of a recently described species of *Machaerium*, known as *Machaerium Whitfordii* Macbride, and is No. 415 in the collections of the Yale School of Forestry. It was collected in the forest along the Negro River in Colombia, in July, 1917, by Dr. H. N. Whitford. The tree, according to the collector, is fairly common in the high hills of Colombia, attains a height of about 20 meters and is of commercial importance. The natives call it "negrillo," a name suggested by the dark color of the heartwood and not restricted to this species. It "belongs to the section *Oblonga* and is most closely related to *M. Moritzianum* Benth. and *M. sordidum* Benth."† It is related also to the true rosewoods of commerce.

The purpose of this paper is to supplement the botanical description of Macbride with a study of the wood structure. The wood presents some interesting features of value for diagnostic purposes. Unfortunately there is no authentic material of other species of *Machaerium* wood available with which to compare the new species.

Gross and lens characters

The wood of *Machaerium Whitfordii* is very hard and compact, without pronounced taste or odor, fine and uniform in texture, more or less cross-grained but apparently of good cabinet qualities. The sapwood, which in this specimen is 13–25 mm. thick, is cream-colored, while the heartwood, which suggests black walnut in color, varies from chocolate-brown to black, and is streaked. The line

* Contribution from the Yale School of Forestry, No. 9.

† Macbride, J. F. Contr. Gray Herb. II. 56: 53. 1918.

of demarcation between heartwood and sapwood is irregular both in general outline and detail and is independent of the concentric rings of growth.

The following figures show the comparative density of heartwood and sapwood after being dried to a constant weight at a temperature of 100° C. The greater density of the heartwood is

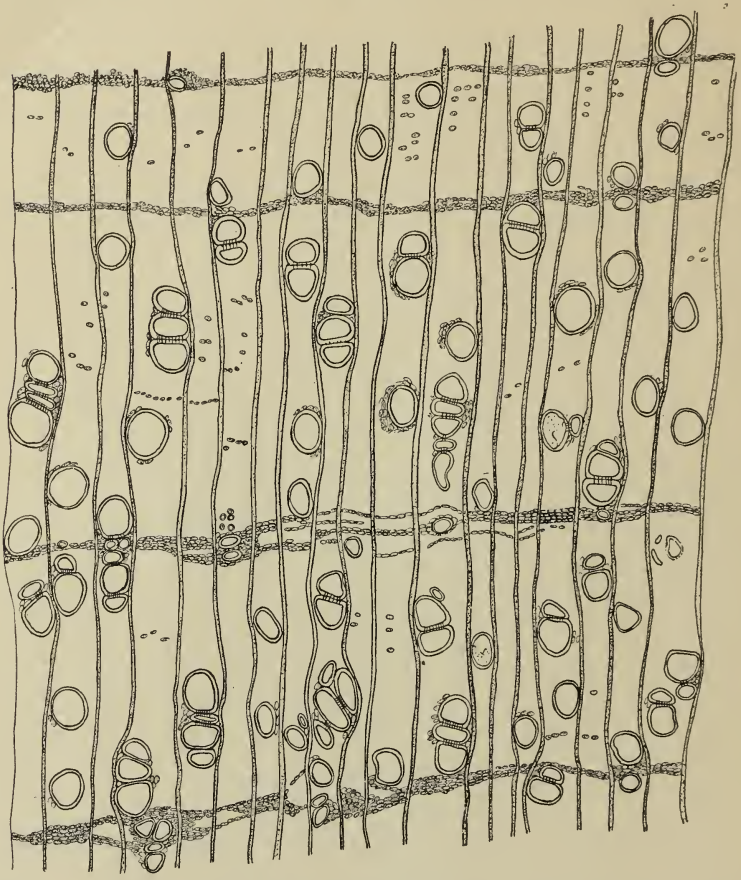

FIG. 1. Plan of cross-section showing four lines of terminal parenchyma limiting growth rings; also paratracheal and diffuse parenchyma.

due to infiltrations and, especially, to gum deposits in the vessels and parenchyma cells.

(1) All heartwood 1.118
(2) Five-sixths heartwood 1.108
(3) All sapwood ..... .975

Growth rings (FIG. 1), which presumably do not correspond to annual periods, are visible and are demarcated by terminal wood parenchyma which forms a single or sometimes double or triple line. These rings exhibit considerable variation in width. The pores are numerous, solitary or in small groups (usually radial), diffused irregularly throughout the ring or, occasionally, in echelon arrangement. They are of fairly uniform size throughout and are barely visible to the unaided eye.

The rays are not visible on the cross section without a lens. They are numerous, fine and uniform. On the tangential section they are seen (under the lens) to be of equal height and arranged in horizontal seriation, thus giving rise to fine and uniform transverse lines, the so-called "ripple marks," which, in proper light, may be seen with the unaided eye.

The bark of the specimen studied is 1.5–2 mm. in thickness and is composed of numerous fine uniform concentric laminations. The outer surface is of a grayish brown color, finely granular, smoothish, with occasional small flakes. The inner surface is somewhat ribbed vertically to correspond with the small irregularities on the outer face of the wood, and exhibits "ripple marks" very distinctly under the lens.

MINUTE ANATOMY

Vessels.—The vessels in cross section (pores) are circular, elliptical or oval in shape; some of them, as a result of crowding in groups, appear to be subdivided radially (FIG. 2). When elliptical, the tangential diameter is 0.075–0.09 mm. and the radial 0.10–0.12 mm. The thickness of the walls varies from 3 μ to 15 μ,

The vessels are without tyloses. Gummy contents, which are light-colored and not very pronounced in the sapwood, are dark brown and conspicuous in the heartwood, often completely filling entire segments. This material is sparingly soluble in hot water and insoluble in alcohol, though shrinking slightly upon dehydration. It appears unaffected by hydrofluoric acid.

The vessel segments are mostly straight, with slight constrictions at each end, the perforations are simple, the annular ridge is narrow, and the plane of contact is horizontal or slightly oblique. The segments are of nearly uniform length, mostly 0.20–0.21 mm., and are arranged in horizontal seriation.

The only markings on the walls are the pits. Those between two vessels are alternate, that is, in diagonal rows, and rarely so crowded as to give a hexagonal outline to the border. The width of these pits averages about 45 μ, while that of the pit mouth, which is narrowly elliptical, is about 30 μ (FIG. 3). Pits in transverse section show rather long and narrow canals, which widen

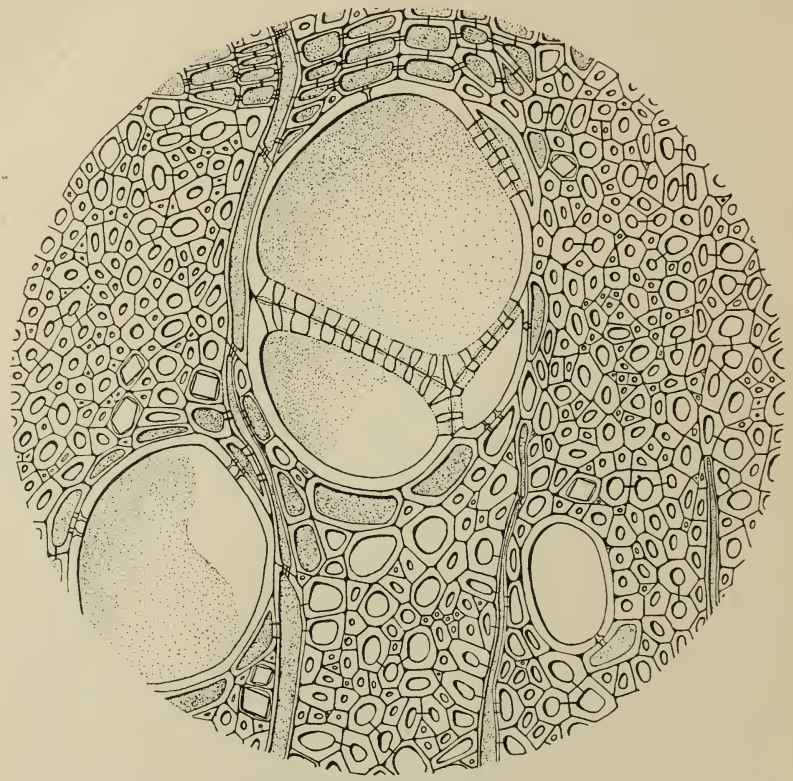

FIG. 2. Detail of a portion of cross-section greatly enlarged showing vessels, solitary and grouped; wood parenchyma, paratracheal, diffuse and terminal; crystals; rays with gummy contents; wood fibres, thick-walled and irregularly disposed. The bordered pits between vessels have slit-like mouths which, in cross-section, are almost as wide as the pit membranes.

abruptly into the cavities along the middle lamella. Sometimes, especially near the ends of the segments, the pits appear almost scalariform in surface view, due to the fact that the orifices on opposite sides of the wall are seen to overlap slightly at the ends into what looks like a continuous slit. In surface view the pit

membranes exhibit a peculiar dotted appearance quite distinct under the low power. These are due to sieve-like perforations, first described by Jönsson* in various woods of the Leguminosae and certain other families.

Tracheids.—Typical tracheids, i.e. with pointed and overlapping ends, are apparently absent. At intervals in the smallest vessels, however, it is not uncommon to find cells corresponding in every way to segments except that the ends are pitted instead of perforated. Intermediate forms with one end perforated and the other closed, except for bordered pits, are occasionally met with.

Wood fibers.—Libriform wood fibers (FIG. 4) form the ground mass of the wood. Their average length is 0.68 mm., the width of the median portion about 15 μ, and the thickness of the wall about 2.5 μ. The lumina are narrow and nonseptate. In cross section (FIG. 2) the fibers, which are polygonal in outline, appear crowded together without regular arrangement, but upon close inspection there is usually seen a fairly definite arrangement between the larger cavities (the enlarged portions of the fibers) and the smaller ones (the dove-tailing tips), due to the fact that the fibers are storied.

The pits are slit-like or narrowly lenticular, either simple or inconspicuously bordered. They are often aggregated in groups of seven to eight at the projecting "shoulder" of the fibers, midway between vertical ray tiers; see FIGS. 4 and 5. These localized pit areas, which may be seen in both longitudinal sections, serve to make the "ripple marks" more distinct. This feature has already been noted by Record† and corresponds to the condition observed by Von Höhnel‡ in a few woods, notably *Bocoa provacensis* Aubl. (*Inocarpus edulis* Forst.).

Wood parenchyma.—Wood parenchyma occurs in three arrangements: (1) as isolated strands scattered in the prosen-

* Jönsson, B. Siebänliche Poren in den trachealen Xylemelementen der Phanerogamen, hauptsächlich der Leguminosen. Ber. Deuts. Bot. Ges. 10: 494–513. 1892.

† Record, S. J. Storied or tier-like structure of certain dicotyledonous woods. Bull. Torrey Club 46: 253–273. 1919.

‡ Höhnel, F. von. Ueber stockwerkartig aufgebaute Holzkörper. Sitzb. Math. Naturw. Cl. Akad. Wiss. Wien 89: 30–47. 1884.

chymatous ground mass, i.e. diffuse; (2) as a layer surrounding the vessels, i.e. paratracheal, but not forming conspicuous masses; (3) in concentric lines or bands, two to seven (mostly two to four) cells wide, sometimes dividing into two or three closely spaced lines for greater or less distances, and apparently limiting seasonal growths; see FIG. 1.

The parenchyma strands are 0.20–0.21 mm. in length, or nearly the same as that of the vessel segments with which they

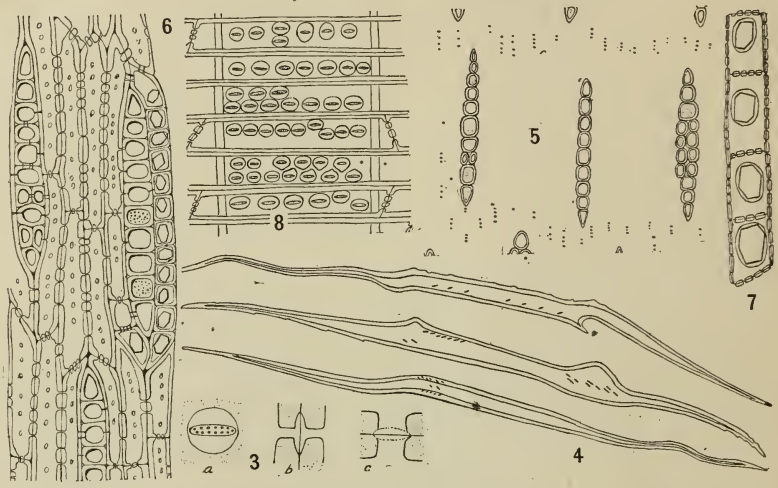

FIG. 3. Diagram of pits between vessels: *a*, surface view, showing rounded border, horizontal elongated mouth, and sieve-like perforations of pit membrane; *b*, vertical section of pit showing narrow canal, *c*, transverse section of pit showing canal almost as wide as the membrane.

FIG. 4. Various forms of wood fibers showing simple pits, which are often aggregated at the shoulders of the fibers.

FIG. 5. Sketch of tangential section showing narrow, mostly uniseriate, rays in horizontal seriation and with special pit areas between the tiers.

FIG. 6. Tangential section through terminal parenchyma, showing the rays and parenchyma strands in seriation; also chambered parenchyma with crystals.

FIG. 7. Detail of chambered parenchyma showing crystals with gelatinous covering.

FIG. 8. Radial section, showing homogeneous ray and the character of the pitting. The pits into the vessel are half-bordered and show sieve-like structure.

are in seriation. The number of cells per strand is usually two, though not infrequently three. The individual cells of the strand are not in secondary seriation (FIG. 6). The average width of a wood parenchyma cell, tangential section, is 17.5 μ; the wall is 2.5 μ thick and abundantly pitted.

Chambered parenchyma strands, with eight to fourteen crystal-bearing cells per strand, are common. The crystals (FIG. 7) are rhombohedral, measuring about 10 μ high and 7.5 μ wide. They appear to be surrounded by a gelatinous coat or layer, which may protect them to some extent from the action of nitric acid, since they are found in macerated material.

Rays.—The rays (FIGS. 5 and 6), as seen in tangential section, are in horizontal seriation, uniform, mostly uniseriate (occasionally biseriate in part), and from eight to twelve cells high. They measure 0.9–0.15 mm. in height and about 15 μ in width at the median portion.

In radial section the rays (FIG. 8) are homogeneous, and the cells are rectangular, 0.075–0.087 mm. in length and about 12.5 μ high. The marginal cells are regular in form and procumbent like the others making up the ray. The walls between adjacent ray cells are finely and abundantly pitted. The lateral walls, where in contact with vessels, exhibit numerous small bordered pits (structurally half-bordered), which are arranged in two horizontal rows, one or two to each cell. The mouth of the pit is narrowly lenticular and the membrance distintly perforated. In the heartwood the ray cells are very gummy, the gum being collected at the cross walls between cells, or along the inner side of the cell wall.

SUMMARY

1. *Machaerium Whitfordii* is a species of Colombian tree recently described by MacBride. The wood is related to the true rosewoods, appears to have good cabinet qualities, and is of commerical importance. The specific gravity of the heartwood (oven-dry) is about 1.20.

2. The wood is characterized by its very fine texture, its dark variegated color, the fine lines of terminal parenchyma, the storied arrangement of its elements (including localized pit areas on the fibers), its homogeneous and usually uniseriate rays, the presence of small half-bordered pits between vessels and ray cells, and the sieve-like perforations of the pit membrane.

Acknowledgment is made to Professor Samuel J. Record of Yale University, under whose direction this study was made, and also to Dr. Forest B. H. Brown for assistance in technique.

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